Industry Overview 9

Learning Objectives

After completing this reading, you should be able to

- Compare the roles of generation, transmission, and distribution in an electricity market
- Identify different types of electricity markets and compare the roles of different market participants

Excerpt is Chapter 1 of Introduction to Electricity Markets, *by John Parsons.*

Chapter 1

Industry Overview

1.1 Introduction

This volume describes the fundamentals of how electricity markets work. This chapter provides a quick overview of the structure of the industry. It also presents the generic terminology we use to describe an industry that looks very different in different countries and regions. Finally, this chapter distinguishes among the different markets for electricity that will be covered in the following chapters.

1.2 The Functional Structure of the Industry

The electricity industry is commonly described in three parts as shown in Figure 1.1:

- **Generation** – the various power plants that produce the electricity, and which are connected to the high voltage lines of the transmission network;
- **Transmission** – the high voltage lines and associated equipment that connect generators to the distribution networks serving load centers, and
- **Distribution** – the low voltage lines and associated equipment that bring the electricity from the transmission network to the final retail customer.

This breakdown is conveniently simple, and therefore helpful in organizing our thinking. However, the reality is a little more complicated. Some large industrial customers can be served directly from the transmission network, as shown in Figure 1.1, so not all load is served from the distribution system. Some small scale generation–like residential solar PV–is located inside the distribution network, so not all generation feeds directly onto the transmission network. The line demarcating the transmission and distribution network is clear in some countries or regions and hazy in others.[1] Storage equipment, such as batteries, acts as both generator and consumer, and can be integrated into some types of generators–as it is in a concentrated solar power installation–or on the transmission system, or on the distribution system. An additional complication arises from the integrated nature of the system and the critical requirement of system stability. Certain activities–notably the provision of reactive power, discussed in Chapter 4–can involve both generators as well as equipment that is part of the transmission system. Despite all of these provisos, the three part structure is a useful framework, and we will usually discuss the system that way.

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[1] Depending upon the country or region, transmission grid voltages range from at least as low as 66kV to as high as 1,000kV. Distribution voltages range from below 1 kV to above 130 kV. Source: Pérez-Arriaga, Ignacio J. Regulation of the power sector. Springer, 2013, Ch 6, and MIT Future of the Grid.

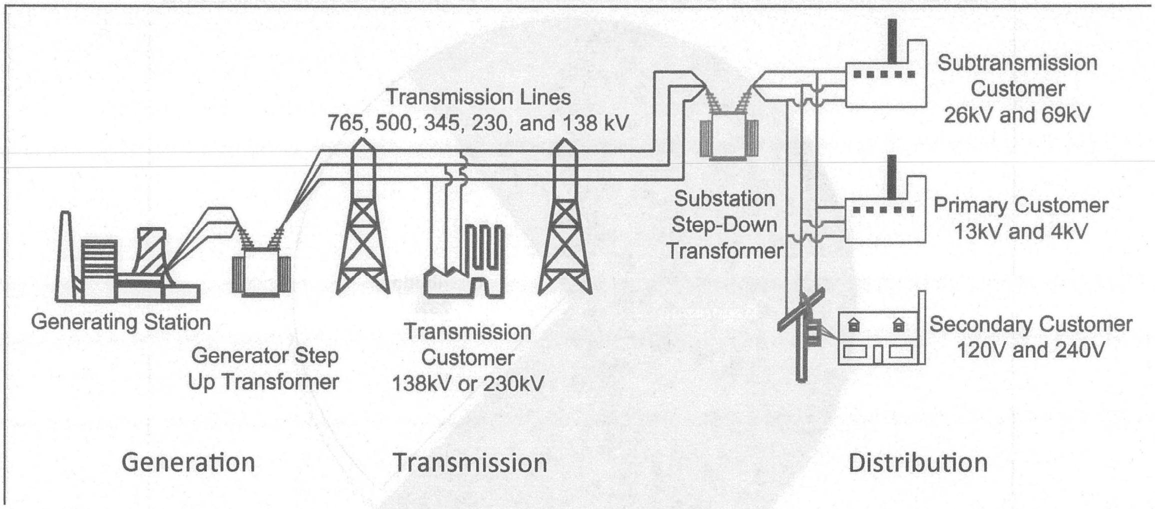
Transmission Lines
765, 500, 345, 230, and 138 kV
Subtransmission Customer 26kV and 69kV
Primary Customer 13kV and 4kV
Substation Step-Down Transformer
Secondary Customer 120V and 240V
Generating Station
Generator Step Up Transformer
Transmission Customer 138kV or 230kV
Generation
Transmission
Distribution

Figure 1.1: The 3-Part Functional Structure of the Electricity Industry.

Note: Voltage categories are for the U.S. and Canada. Other countries will have different categories.
Image credit: US-Canada Power System Outage Task Force, Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations, 2004.

Figure 1.2 shows the share of the electricity price attributable to each of the three parts of the industry, using data for the U.S. in 2015. Generation is clearly the largest portion, accounting for 62% of the price. Transmission is the smallest, accounting for 10%. Distribution accounts for 28%. The shares can very significantly across countries and regions. Transmission costs can be as low as 5 to 10% in densely populated countries where generation can be located relatively close to demand, and can rise up to 20% in countries such as Chile or Brazil where the distance from best generation to load is long.[2] The costs of the distribution network will be smaller in more densely populated regions, too.

The **bulk power system** refers to the delivery of power across the transmission system, from generators to the substations where it is transferred to the distribution network. It does not include the operation of the distribution network. Trade on the bulk power system is called the **wholesale market**. This is the trade in electricity involving generators, wholesale marketers, and large customers located at different points on the high voltage transmission network. It does not include almost any retail customer, with the exception of a few large industrials connected directly to the wholesale network. The **retail market** is where retail customers purchase power off of the distribution network from a larger entity, such as their municipal electricity company or local distribution utility or competitive retailer. The wholesale market sees these retail customers only in large aggregates at the various points where the transmission system delivers the power to the distribution network.

At present, this volume does not discuss the distribution network in any significant detail. Nor does it give much attention to the retail market, except as it directly shapes the wholesale market. However, things are quickly changing at the distribution level and that is beginning to have repercussions in the wholesale market. Technology is quickly advancing and enabling retail customers to respond to changing wholesale prices. Electricity systems are exploring how to incorporate these technologies and therefore how to extend down into the distribution network the active market structures that currently play an important role only at the wholesale level. In the future, as this exploration yields substantive changes at the distribution level and in the retail market, it will become necessary to expand our discussion accordingly.

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[2] Pérez-Arriaga, Ignacio J. Regulation of the power sector. Springer, 2013, p. 263.

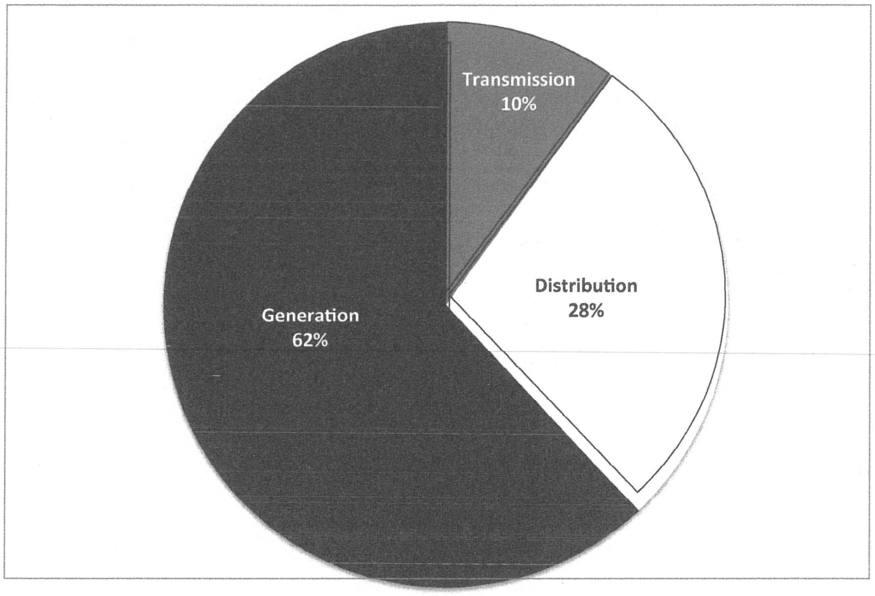

Figure 1.2: The 3-Part Shares of Total Electricity Cost.

Data source: U.S. Energy Information Administration, Annual Energy Outlook 2015, Reference Case, Table 8: Electrical supply disposition, prices and emissions.

1.3 The Institutional Structure of the Industry

This volume is intended to be of use to risk professionals everywhere. It must confront the challenge that the institutional structure of the electricity industry varies widely across countries, and almost as widely within certain countries. Ownership structures include state-owned corporations, cooperatively-owned corporations, privately-owned corporations operating under tight regulatory rules, and privately-owned corporations competing in relatively free market structures, as well as non-profit companies and a variety of government agencies. Operational responsibilities are structured in many different ways. In some places, a single corporation controls all parts of the system, from generation to transmission to distribution to retail service, including the responsibility for assuring system stability. In other places, these different parts of the business are purposefully separated one from another, so that generation owners, transmission owners, distribution owners and retail service providers are all distinct from one another, and a separate entity is responsible for assuring overall coordination and system stability. It would be unwieldy to attempt to describe all of the different structures and institutions as they appear everywhere, so we take a different tack. Despite the many apparent differences, the institutional structures in all countries and regions must address the same technological and economic challenges and develop some allocation of responsibilities to manage them. Therefore, it is more helpful to identify those common technological and economic challenges and we use generic terms for the institution responsible for managing them, regardless of the ownership or regulatory framework. Here are some examples:

- **Genco** – A generic label for an entity responsible for investing in and operating generation capacity, whatever may be the ownership structure or market rules that govern the system. Our genco could be privately-owned, or state-owned or cooperatively-owned. Our genco could be a stand-alone business with no assets beyond the one generator we are discussing, or it could be a vertically integrated business.

- **Transco** – A generic label for an entity responsible for investing in and operating transmission equipment, regardless of the ownership structure or whether it is integrated with other assets.

- **Load Serving Entity** (LSE) - A generic label for an entity that represents consumers in procuring electricity wholesale. An LSE could be a municipal power corporation, a state agency, a privately-owned competitive retailer, or a local distribution utility.
- **Wholesale Marketer** or **Trader** – Generic labels for an entity focused exclusively on buying and selling power in the wholesale system, without ownership of any physical generation or any retail customers of its own. A wholesale marketer may contract for control of a generator and may contract to supply an LSE's load, but the wholesaler does not start having that obligation. A wholesale marketer may be a subsidiary of a larger company that also owns generation or transmission assets, but the focus of its own operations is on the wholesale trading.
- **System Operator** – A generic label **system operator** for any entity responsible for any element of the coordination of generators and load on a transmission network. Different countries and regions place distribute responsibility for the various elements of this coordination with different entities in the industry and have different labels for the entities that assure coordination, but all countries and regions have some assignment of this responsibility. A system operator could be a state-owned corporation or a publicly regulated private utility that directly owns and control all generators and transmission equipment. Or, it could be a public authority that coordinates privately owned generators and a privately owned network of transmission lines through some sort of a market mechanism to establish which generators produce what when, and how the transmission network is used. A system operator could run the markets itself, or it could supervise another private company to run the markets.[3]

We generally treat the decision making of any of our generic institutions as if it were independent of the decisions of the larger company of which it may be a part. But that need not be the case, and we sometimes consider what happens when the decisions of different generic institutions under the same corporate ownership are taken together. The use of these generic institutional labels is purely one of convenience and clarity in discussing diverse electricity systems.

1.4 The Role of Markets

The focus in this volume is on electricity markets. We use the generic label **market** to cover any collection of contracts, bids, trades and transactions that organizes the operating decisions of gencos, transcos and LSEs. In some cases, the market may be a collection of contracts negotiated bilaterally between gencos and LSEs, without any formal coordination or rules imposed. In other cases, the market may be carefully structured, with formal bidding rules and algorithms to determine the outcome. Much of the volume will be focused on understanding the different market structures.

Markets can be integrated with the many non-market methods available for managing electricity operations. Markets can play a larger or smaller role alongside these other non-market methods. So, when we discuss any particular market, we keep an open mind about the other parts of the system. However, since markets are our focus, we do not analyze these other non-market structures in any significant detail.

When we speak about the electricity market, we are really talking about several markets in different types of products. The main one is known as the **energy market**. In the energy market, buyers pay sellers to deliver some number of megawatt hours of electricity to a specific location during a specific period of time. The energy market is what most people think of when they think of the electricity market. Chapters 6 and 7 discuss the energy market. Markets in **ancillary services** are another set of electricity markets. Chapter 4 on the transmission system lays the foundation for understanding the different types of ancillary services and how they are different from the energy market. Chapter 8 discusses how ancillary services markets are organized. The generation **capacity market** is another electricity market. Chapters 6 and 8 discuss markets in capacity. Finally, there are markets in **transmission rights** related to the congestion on the transmission system. Chapter 8 also discusses this market. Chapter 9 is devoted to environmental regulations and **emissions markets** since these play an important role in the electricity industry. The role of financial trading is left for its own separate volume.

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[3] Our generic system operator should not be confused with the particular institution in the U.S. known as the Independent System Operator (ISO). ISOs perform some of the responsibilities of our generic system operator, but other institutions in the U.S. participate in fulfilling other responsibilities, too. And, other countries that do not use the particular institution known as the ISO, nevertheless do have some one or more institutions fulfilling the responsibilities of our generic system operator.

Study Review

Some key terms introduced in this chapter were:

- generation
- transmission
- distribution
- bulk power system
- wholesale market
- retail market
- genco
- transco
- load serving entity (LSE)
- wholesale marketer or trader
- system operator
- market
- energy market
- ancillary services market
- capacity market
- transmission rights market
- emissions markets